

Ethnopharmacological survey of plants used for the treatment of schistosomiasis in Niono District, Mali

Sekou Bah^{a,b}, Drissa Diallo^b, Seydou Dembélé^b, Berit Smestad Paulsen^{a,*}

^a Department of Pharmaceutical Chemistry, School of Pharmacy, University of Oslo, P.O. Box 1068 Blindern, N-0316 Oslo, Norway

^b Département de Médecine Traditionnelle, Institut National de Recherche en Santé Publique, BP 1746, Bamako, Mali

Received 7 November 2005; received in revised form 17 November 2005; accepted 17 November 2005

Available online 18 January 2006

Abstract

In Mali the use of traditional medicine is a wide spread phenomenon, not only because of its cultural importance, but also as the majority of people cannot afford the western drugs or medicines. In Mali, the Office du Niger area constitutes the main zone of schistosomiasis transmission where both *Schistosoma mansoni* and *Schistosoma haematobium* are encountered. An ethnopharmacological survey, using questionnaire, was conducted in the Office du Niger area of the Niono District to determine the plants used against schistosomiasis amongst traditional healers. Forty healers from 21 villages of six different health areas were interviewed. All interviewed healers knew about urinary schistosomiasis, while only six knew about the intestinal form. The presence of blood in urine was reported as the main symptom of urinary schistosomiasis. Fifty-five plants belonging to 30 families were reported to be used alone for treating urinary and intestinal schistosomiasis, while nine combinations of plants were used against the urinary form of the disease. *Cissus quadrangularis* and *Stylosanthes erecta* were the plants most frequently used and were reported for the first time, to be used against schistosomiasis in Mali.

© 2005 Elsevier Ireland Ltd. All rights reserved.

Keywords: Traditional medicines; Schistosomiasis; Medicinal plants; Mali

1. Introduction

Schistosomiasis is together with malaria, one of the most prevalent parasitic diseases in humans. It has been estimated that there are over 200 million cases of schistosomiasis in the world. Estimates suggest that about 85% of all schistosomiasis cases now occur in the Sub-Saharan African countries (Chitsulo et al., 2000). Mortality due to schistosomiasis was estimated to 15,000 deaths per year, which does not include the indirect mortality due to schistosomiasis infection sequelae such as liver disease, portal hypertension, haematemesis, non-functioning kidney, cervical and squamous cell bladder carcinoma. If taken into account, the overall estimate of deaths due to schistosomiasis can reach 200,000 per year (Jukes, 2002). This would place schistosomiasis as the third most important disease within the World Health Organization's Tropical Diseases Research Center portfolio. Furthermore among human

parasitic diseases, schistosomiasis ranks Second behind malaria in terms of socio-economic and public health importance in tropical and subtropical areas (WHO, 2002). There are two types of schistosomiasis: urinary and intestinal schistosomiasis. Four major species are involved in the pathogenesis of schistosomiasis, three of which, *Schistosoma japonicum*, *Schistosoma mansoni* and *Schistosoma intercalatum*, cause intestinal schistosomiasis, while the fourth, *Schistosoma haematobium*, causes urinary schistosomiasis.

In Mali, the disease can be found all over the country, but the infestation percentage is variable from one place to another (Landouré et al., 2003). According to estimates about 5.8 millions people are affected with schistosomiasis (Chitsulo et al., 2000). Two species of schistosomes are responsible for schistosomiasis in Mali, *Schistosoma mansoni* and *Schistosoma haematobium*. The snail intermediate hosts encountered are *Bulinus globosus* and *Bulinus truncatus* for *Schistosoma haematobium*, and *Biomphalaria pfeifferi* for *Schistosoma mansoni* (Diallo, 2000). The "Office du Niger" was established in the late 1930s and is one of the major areas for schistosomiasis transmission. The Office du Niger is the area for the production of rice based

* Corresponding author. Tel.: +47 2285 6572; fax: +47 22854402.
E-mail address: b.s.paulsen@farmasi.uio.no (B.S. Paulsen).

on an irrigation dam (Markala dam on the river Niger) and both forms of schistosomiasis are encountered. There are numerous examples showing that irrigation and other water resources development projects could result in increased transmission of schistosomiasis and other water-related diseases (Chimbari et al., 2004; Coulibaly et al., 2004; Yapi et al., 2005). At the Office du Niger area, the prevalence of infection with *Schistosoma mansoni* and *Schistosoma haematobium* was estimated to be 52 and 63%, respectively (Diallo, 2000). In Mali the schistosomiasis control is mainly based on the use of praziquantel which is listed in the essential drug list (van der Werf et al., 2004). The cost of the drug, though being as a generic product, can still be expensive for the majority of people in Mali rendering it not affordable for the management of particularly intestinal schistosomiasis. In Mali, the majority of people use medicinal plants for the treatment of their illnesses and the holders of the knowledge about these plants are the traditional healers. To control the disease, medicinal plants are used as molluscicides (against the snail, the intermediate host) and also for relieving the symptoms of the disease. In two previous surveys carried out in Mali in the districts Kayes and Bandiagara, plants used as molluscicides and against schistosomiasis by the traditional healers were reported (Sylla, 1991a,b). These studies highlighted the huge variation between the plant species used by healers from one locality to another as well as the mode of preparation of these plants.

Several studies have been carried out to evaluate the molluscicidal properties of medicinal plants. Of the plants with recognized molluscicidal effects and widely studied are *Phytolacca dodecandra* L'Herit (Phytolaccaceae) (Esser et al., 2003), *Swartzia madagascariensis* Desv. (Fabaceae) (Marston and Hostettman, 1987) and *Ambrosia maritima* L. (Asteraceae) (Whitfield, 1996). More focus is now paid on the possibility of the use of medicinal plants to control the disease in human. A study on South African medicinal plants revealed the efficiency of 21 plant species against schistosomula worms' (Sparg et al., 2000).

Studies of local perception and knowledge of schistosomiasis have been done mainly with villagers or mothers in general (Clark et al., 1997) or with school pupils and their parents (Dabo et al., 1995; Sangho et al., 2002; Sow et al., 2003). Traditional healers were seldom the source of information of such studies, although they play important role in the treatment of many diseases including schistosomiasis. One study was reported on the knowledge of schistosomiasis amongst healers in Zimbabwe (Ndamba et al., 1994). The development of new drug for control of schistosomiasis owing to cost and possible resistance to praziquantel is worthwhile. One alternative to search for new drug is looking at medicinal plants.

To the best of our knowledge there has not been any survey on medicinal plants used neither for treating schistosomiasis nor on the knowledge of the traditional healers on schistosomiasis in the Office du Niger area. In the present survey we conducted a survey among traditional healers from the Niono District, focusing on medicinal plants used to alleviate the symptoms or cure schistosomiasis on human. The purpose of the study is to find active species which can be used as an effective treatment (or drug). For this reason we decided to determine the knowledge

of the traditional healers about schistosomiasis and to identify the plants used by them to treat the disease. The plants most frequently cited by the healers categorized with adequate level of knowledge on schistosomiasis in this study will be subjected to further investigations for their pharmacological activities and subsequent phytochemical analysis.

2. Methodology

2.1. Study area

The study was conducted in the district of Niono whose district head quarter is the city of Niono (14–18° north and longitude 05–59° west) in March 2004. The district has a population of about 300,000 inhabitants. The Office du Niger area of Niono was selected based on the facility of access and also the epidemiological status of the area for it is the area of high schistosomiasis transmission. The study area with villages visited is pictured in Fig. 1 (map of study area). Twenty-one villages from six health areas (catchment's areas) were included in the study. These health areas were Boh, Diabaly, Molodo, Ndébougou, Niono and Séribala, and four main ethnic groups populate the district of Niono: namely Bambara, Minianka, Mossy and Peulh (Fulani). Each ethnic group has its own language, but Bambara language is the main communication language. Farming is the main occupation of the three first ethnic groups while Peulh are mainly herdsmen. The main agricultural activity practiced by people is rice production. Two rice production zones exist in the Office du Niger area of Niono: a zone called *zone exondée*, meaning in French the non-irrigated zone, and a *zone inondée*, meaning in French irrigated area zone. In the irrigated area, the rice fields are irrigated by canals (waterways used for the irrigation of rice) and two harvests are possible per season, while in the non-irrigated zone the production is only during raining season (Coulibaly et al., 2004). Sixteen of the 21 villages visited (Fig. 1) were located in the irrigated area while the other five (Barikoro, Diambé, Dongaly, M'Bewala, and Toumakoro) were in the non-irrigated zone. The daily activities of people lead them in contact with water and the main sources of water contact are: rice fields, irrigation canals (for washing clothes and dishes, taking ablutions for praying, crossing with cattle, drinking, etc.). The drinking water is mainly provided by wells, and in some villages public fountains provide safe water for drinking. In the area the wells are not deep enough and are not protected against contamination from pollution.

2.2. Selection of traditional healers

The healers from the villages visited were our respondents. A traditional healer is defined as a person with competence to practice traditional medicine; the competence being evaluated on the ground of the healer's achievement in the respective community. In Mali, the DMT (Département de Médecine Traditionnelle) is the official institute connected to the National Institute of Research in Public Health (INRSP: Institut National de Recherche en Santé Publique). This department has as main objective the establishment of a mechanism to assure

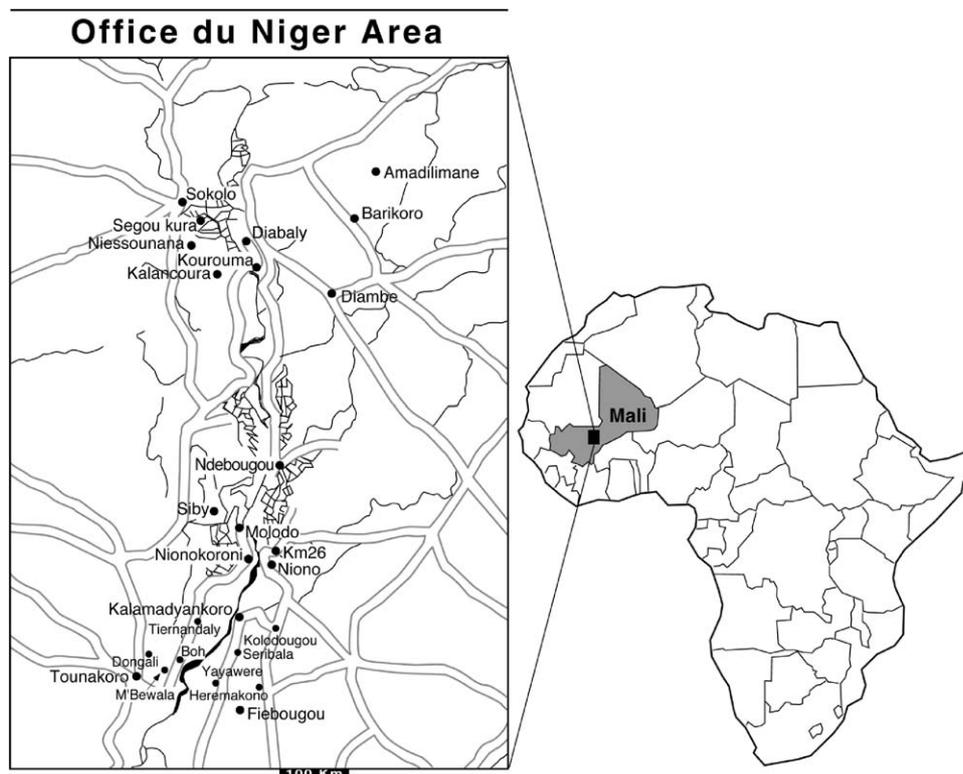


Fig. 1. Map of the study area with indication of the localities visited during the survey.

that traditional medicine is complementary to conventional medicine, assuming that medicines can be produced from local resources, especially from medicinal plants. The main activities of the DMT are: registration of traditional practitioners, medicinal plants, research and development of Improved Traditional Medicines (ITM). By the time of the study, no previous registration of the healers in the district of Niono by the DMT had taken place as DMT had not visited the area before. We went therefore through a local association of healers in Niono called “Kala Keneya” to get contacts. In each village, we paid visit to the head of the village as it is a tradition in Mali, and asked if there were any traditional healers in the village. If there were, we paid a visit to them. Prior to the interview, the objective of the study was explained and his or her co-operation was sought. If consenting, we then proceeded for the interview. The choice of the interview setting was left to the healer’s appreciation. All the healers were interviewed at their working place or at home. All healers encountered during the study were interviewed, and totally 40 interviews were conducted in 21 villages.

2.3. Data collection technique

The data were collected in March 2004 during a 2-week fieldwork. A semi-structured questionnaire (available by request to BSP) composed of three main parts were administered by the authors having previous experience of working with traditional healers, knowledge about schistosomiasis control and being fluent in Bambara language (the local language spoken by the healers in the study area). The questionnaire was pre-tested with five healers in Bamako and subsequent corrections

made before starting the fieldwork. The pre-testing permitted us to find out whether the questions are well understood and also to identify the words used in Bambara language for both urinary and intestinal schistosomiasis. This pilot study permitted us to reduce the possible misunderstanding between local conception of the disease and its bio-medical definition (Gessler et al., 1995; Vigneron et al., 2005). After the pre-testing, two words were found to be used in Bambara to designate urinary schistosomiasis *sukunè/gnèguènè* (urine) *bleni* (red) and *damadialan* meaning literally infection of the urinary tract. The name used for intestinal schistosomiasis was *konona* (in the stomach) *damadialan* (schistosomiasis) that could be translated by the form of the disease in the stomach. The final version of the questionnaire comprised open and closed questions and the following issues were addressed:

- (A) Survey data: interviewer’s name; health area and village (locality of residence). This part of the questionnaire was filled out by the interviewer before starting each interview.
- (B) Socio-demographic data: direct specific questions were asked about age, time of practice as healer (experience) and status of collaboration with local health center.
- (C) Knowledge of schistosomiasis. The aim of this part was to assess the healer’s level of knowledge on symptoms and mode of transmission of schistosomiasis, and to determine in his own word the names and different forms of schistosomiasis. The design of the questionnaire was such that bias was minimized by avoiding leading questions. In this respect a first general question was addressed to the healer about the main health problems in the area he

lives. The healers were given the possibility to mention as many diseases as they wished by order of importance. When schistosomiasis (either urinary or intestinal) came out among the answers, subsequent questions related to different forms of the disease, symptoms and mode of transmission were asked. If schistosomiasis was not mentioned at all, a probing question was asked (e.g. is there any other disease that represent a problem?). If after probing diseases other than schistosomiasis, were mentioned, a third approach was used. This consisted of directly asking the healer what he/she knew about schistosomiasis. Urinary schistosomiasis was mentioned by all the healers in the first instance and therefore no probing was needed (refer to results section).

- (D) Plants used to treat schistosomiasis: the aim of this chapter of the questionnaire was to determine the types of treatments (use of plant or conventional drug) healers used against schistosomiasis, the name of the plant used, parts of plants used, mode of preparation of the remedy and the duration of the treatment. The last part of this chapter was also dealing with when and how the plants can be collected.

2.4. Definitions of variables and data analysis

The main variables were: main health problems, types of schistosomiasis, level of knowledge on the symptoms of schistosomiasis, level of knowledge on the mode of transmission of schistosomiasis and plants used to treat schistosomiasis. The healers were categorized based on their level of knowledge on the symptoms of schistosomiasis (urinary or intestinal) as *adequate* or *inadequate*. A healer was considered having adequate knowledge on symptoms of urinary schistosomiasis if he/she did report the presence of blood in the urine (haematuria) of the patient among the symptoms of the disease. The haematuria is one of the characteristic symptoms of urinary schistosomiasis and has previously been used as criteria in surveys that addressed the knowledge of traditional healers on schistosomiasis (Ndamba et al., 1994). On the other hand a healer was considered having inadequate knowledge on symptoms of urinary schistosomiasis if he/she did not at all mention the presence of blood in the urine among the symptoms. A healer was considered having adequate knowledge on symptoms of intestinal schistosomiasis if he/she did report bloody stool and abdominal pain among symptoms of the disease. A healer was considered having inadequate knowledge on symptoms of intestinal schistosomiasis if he/she did not mention bloody stool and abdominal pain among the symptoms. Bloody stool and abdominal pain are symptoms that have been used previously in assessing level of knowledge of and awareness about intestinal schistosomiasis in epidemiological survey (Sangho et al., 2002; Sow et al., 2003). Concerning the mode of transmission the healers were also categorized as healers with adequate or inadequate knowledge. A healer was considered having adequate knowledge on the mode of transmission of schistosomiasis (either urinary or intestinal) if he/she had mentioned contact with water (except drinking water) among the modes of transmission of the disease. A healer who did not mention water contact at all was considered having inad-

equate knowledge. The sources of possible water contact in the study area are mentioned in the description of the study area. The plants most frequently reported, their parts used, as well as the mode of preparation, regardless of the level of knowledge about schistosomiasis, are presented. The remedies reported by healers with adequate level of knowledge on symptoms of urinary schistosomiasis will be given more attention in future studies. A remedy reported by healers having inadequate knowledge on symptoms of urinary schistosomiasis was also considered for analysis if the same remedy was reported by a healer with adequate knowledge. The remedies made of one plant only are referred to as single, and those consisting of two or more plants are referred to as combinations.

Data entry and analysis were performed using the SPSS 12.01 Software for Windows. A univariate analysis was used to analyze all the answers for each question in the questionnaire (Vigneron et al., 2005). The quantitative data were expressed as mean \pm standard deviation and in percentages. The correspondence between the level of knowledge about symptoms and mode of transmission of schistosomiasis and the plants used was checked by cross-tabulation and Pearson's Chi-square was used to determine the statistical difference between the different groups and the level of significance was set at $p < 0.05$. The plants reported during the present survey were authenticated by Professor Drissa Diallo (Head of the DMT) and a voucher specimen was made and deposited at the herbarium of the DMT.

3. Results and discussion

The survey permitted determination of level of knowledge of the healer on schistosomiasis, revealed the medicinal plants used to treat the disease, as well as the way the remedies were prepared. Since the survey was conducted in one district in Mali, the generalization of the results could be limited.

3.1. Characteristics of healers

All the healers encountered in the different villages visited were interviewed and none of them has withdrawn from the study after completion of the interview. The distribution of the healers by health area was as follows: Niono (10), Diabaly (10), Séribala (6), Boh (5), Kourouma (4), Molodo (3) and N'Débougou (2). Three ethnic groups were represented in the study: Bambara (30), Minianka (6) and Peulh (4). The Minianka and Peulh healers were all fluent in Bambara language. Of the forty healers interviewed, two were females. The healers had a mean age of 57 ± 14 years; the youngest amongst them was 26 while the oldest was 82. Twenty-nine (72.5%) healers had been practicing as traditional healer for more than 10 years, while only three (7.5%) had less than 5 years of experience. Eleven healers (27.5%) reported having collaboration with their local health center in various domains. The main domains of collaboration were on disease control, involvement in information, education and communication on health (IEC) campaigns, particularly on immunization and maternal health.

3.2. Knowledge and perception of healers about schistosomiasis

3.2.1. Main health problems reported by the healers

The main health concerns reported by the healers were malaria, schistosomiasis, women's diseases, diarrhea and hemorrhoids. Malaria was reported by twenty-three (58%) healers as the main health problem, while only eight healers (20%) perceived *sukunè bleni* as a main health concern in their respective localities. However, all the interviewed healers (100%) reported *sukunè bleni* amongst the main health problems either as first, second or third main problem. In Mali, especially in the Office du Niger area, malaria and schistosomiasis are the two most prevalent diseases (Coulibaly et al., 2004). This appears to be in accordance with the global situation in the world of the two infections where schistosomiasis ranks second behind malaria. Interestingly none of the healers had considered intestinal schistosomiasis (*konona damadialan*) as a health concern in the area, although six healers (15%) said they knew that form of the disease. This is presumably a confirmation of the lack of knowledge of healers about that form of the disease. The women's diseases included menstrual pains, amenorrhea and sexually transmitted infections such as gonorrhoea and syphilis. In Mali, the health problems are dominated mainly with infectious diseases, malnutrition and diarrhea (Diallo and Paulsen, 2000). Hygienic conditions and lack of safe water could explain the presence of intestinal infections, while the sexually transmitted infections could be related to the presence of migrant workers.

3.2.2. Types of schistosomiasis

All the 40 interviewed healers reported to know urinary schistosomiasis, while only 6 healers (15%) reported knowing intestinal schistosomiasis. Eighty-five percentage of the healers who claimed knowing urinary schistosomiasis said also that they did not know any other form of the disease. Urinary schistosomiasis was reported as *sukunè bleni* by 87.5% of the healers while 7.5% reported the disease as *ngorochien* (meaning itching in the crotch) that may be in reference to the pruritus observed in case of urinary infections, and 5% called the disease *damadialan*. Intestinal schistosomiasis was reported as *konona damadialan* by all six healers. Sylla (1991a) reported *sukunè bleni* and *damadialan* as names for urinary schistosomiasis in Kayes. These names are also the ones used to designate the disease by the National Schistosomiasis Control Program and other research groups that have used these words in Mali (Sangho et al., 2002). *Sukunè bleni* and *damadialan* are very specific words used in Bambara language for urinary schistosomiasis. However in the present study only two healers have referred to the disease as *damadialan*. In Kayes urinary schistosomiasis was reported by the majority of the healers as *damadialan*. This discrepancy between the words might be due to the difference in dialect of Bambara between Kayes and Niono. *Konona damadialan* referred to the translation of the bio-medical appellation of the intestinal schistosomiasis. This is probably an indication of the lack of knowledge about this disease among healers. The majority of the healers (87.5%) in our study referred to urinary schistosomiasis as haematuria (*sukunè bleni*) which could be

related to the bio-medical terms of the symptoms of the disease. Although in biomedicine the haematuria is not referred as the disease in contrast to the healer's perception. Since schistosomiasis is an infectious disease, the healers lacking knowledge about the pathogenic agent, would probably refer to the symptoms as the disease. In the present study it appears that urinary and intestinal schistosomiasis are perceived as two distinct diseases in term of symptoms and mode of transmission. Intestinal schistosomiasis is not known by the majority of the healers (85%).

3.2.3. Symptoms

Haematuria was the main symptom associated with urinary schistosomiasis as reported by the healers. This was reported by 33 (77.5%) healers and thus were categorized having adequate level of knowledge on symptoms of urinary schistosomiasis. Our finding is consistent with previous studies carried in Mali when it comes to symptoms (Sylla, 1991a,b). However in Bandiagara and Kayes the level of knowledge of the healers was not assessed. The finding is also consistent with previous studies carried out in other African countries (Ndamba et al., 1994; Clark et al., 1997). Our study, however, differed from that of Clark et al. (1997) as the informants were composed of traditional healers and the focus-group discussion was not used, while in Clark's study the informants were composed of the general population. In Mali healers are usually not willing to discuss their knowledge on disease and plants in the presence of other fellow healers. Therefore a focus-group discussion could not be performed. The difference between our study and that of Ndamba et al. (1994) is mainly based on the sample size; they had a much larger number of healers, as they performed their study in more than one district. In our study we tried to get as many healers as possible. This can be illustrated by the number of villages visited. The study was mainly performed in rural areas and rarely more than one healer is present in a given village. Other symptoms of urinary schistosomiasis reported by the healers were dysuria (pain on urination), polyuria (increased urinary frequency) and redness of eyes. Clark et al. (1997) reported frequent urination and redness of eyes as symptoms of urinary schistosomiasis as reported by their informants in South Africa. These symptoms could however be observed in other types of urinary infections as well. Eight healers (20%), although having reported the most common symptom of the disease, still ignore the infection as they considered urinary schistosomiasis as the starting point of syphilis. This is consistent with findings of previous studies carried out in Mali amongst traditional healers in Kayes (Sylla, 1991a). Two (5%) respondents said that the disease could be sexually transmitted and reported leucorrhoea as the symptoms of the disease. This could be explained by the fact that the disease is considered to be linked to syphilis or gonorrhoea or other urinary tract infection by those healers. There was no difference between the healers in the level of knowledge on symptoms of urinary schistosomiasis when compared by age ($p > 0.05$) or by experience (time of practice). This might be due to the low number of the person interviewed in this study. However, age and experience seemed to contribute to an increased level of knowledge.

Concerning intestinal schistosomiasis only six (15%) of the healers said that they knew it and they were all from Niono. Ndamba et al. (1994) found that the healers with knowledge about intestinal schistosomiasis were from urban areas. Intestinal schistosomiasis is not easy to diagnose clinically based on symptoms, therefore the healers lacking any means of biological examination would not know about this form. Four of the six healers, reported abdominal pains and bloody stool as symptoms of the intestinal schistosomiasis. They were considered having adequate knowledge about the symptoms. It is worth mentioning that these healers had been collaborating with their local health center, and this could have provided these healers with knowledge of the disease e.g. the symptoms. This is a sign that collaboration between traditional and conventional medicine is possible and can be useful for healers as well. Furthermore, the level of education could also be in favor of increasing knowledge about the intestinal form of the disease. However the majority of the healers interviewed were considered having inadequate knowledge about symptoms of intestinal schistosomiasis. Some of the symptoms reported for intestinal schistosomiasis can be encountered in other intestinal parasitic infections as well. The most common intestinal infections in the area are hookworm, strongiloides, teniasis, giardia and ameba infections. However, these infections have their own names in Bambara which are different from the name used for intestinal schistosomiasis. They are usually called *toumouw* meaning worms. The intestinal schistosomiasis was not referred by the healers as a worm infection (see mode of transmission below). Other symptoms reported were fever and headache and this probably because of the high prevalence of malaria in the area of study. The patients coming for consultation to the healer may have multiple infections.

3.2.4. Mode of transmission

Twenty-one interviewed healers (52.5%) were linking the transmission of urinary schistosomiasis to water, in particular the irrigation canals and other ponds or streams. They reported that the water of the canals or streams contained the small animals designated in Bambara *fin nienemani* meaning literally small living things, which cause the disease. Since none of the healers mentioned the snails as intermediate host of the parasite. These small animals could be either said in reference to the cercariae or even the snails. However, no further question was asked about the description of these small animals. Relating the cause of urinary schistosomiasis to these small animals could be in accordance with the bio-medical concept about the cause of the disease. These 21 healers were considered with adequate knowledge on the mode of transmission of urinary schistosomiasis. A cross tab analysis showed that the level of knowledge on symptoms of the disease was not always reflected on the level of knowledge on the mode of transmission. Of the 33 healers with adequate level of knowledge on the symptoms of the disease, 11 were categorized with inadequate level of knowledge on the mode of transmission. This is probably due to the fact urinary schistosomiasis has the haematuria as a specific symptom. However, the healers in Niono had better knowledge about the mode of transmission of the urinary schistosomiasis than the healers in Kayes. None of the healers interviewed in Kayes linked the

transmission of the disease with water (Sylla, 1991a). The difference between healers in Niono and Kayes with regard to the mode of transmission could be explained by the fact that there is an ongoing malaria research program in the area of Niono which gives health education about both malaria and schistosomiasis. Therefore the healers could have learnt some aspects of the disease with respect to its transmission. However, in our study the healers were not asked their source of knowledge on the mode of transmission of the disease. Our results on the other hand are consistent with findings reported in South Africa (Clark et al., 1997). Clark et al. (1997) reported that 75% of the interviewed people in South Africa have linked the transmission of the disease to water. These water sources were used for swimming, washing clothes and praying, but not for drinking. Eleven interviewed healers (37.5%) during our survey said that the disease could be transmitted by exposition or working under the sun or by physical effort, i.e. riding bicycle. Physical effort and exposition to sun could be factors that favor the excretion of eggs of schistosomes in the urine and therefore the presence of blood in the urine. For infection with *Schistosoma haematobium*, most eggs are passed out in the urine and found in the deposit of centrifuged or sedimented urine, preferably around midday (Muller and Morera, 1994). During field work examinations, in order to increase the yield of eggs in the urine, subjects are sometimes asked to walk for a few meters or sit under the sun for a few minutes before the urine sample is collected. In a mass chemotherapy campaign in Egypt, the urine specimens were collected between 10:00 a.m. and 1:00 p.m. at the field examination site (Talaat and Miller, 1998). In our study area most people are farmers, an activity that exposes the population for a long time to sun and heavy physical efforts. The healers could have observed that most people that have the disease get blood in their urine after a long day of work in the field, after riding a bicycle for a long distance or after staying with cattle. After a long day of work in the rice fields or behind the cattle, the farmers usually ride bicycles to go home and on their way home, they have sometimes to take shower in the canals or simply swim to cross the canals. If the canals are populated with infested snail, the risk to get infected with schistosomiasis becomes high. Since the healers probably are not aware of the fact that the disease is due to a parasite, they would therefore refer to the factors that could increase the apparition of the symptoms as the cause of the disease.

Two healers also said that for boys it was normal having haematuria during their physical development. The reason they claimed this was that haematuria in a young boy for them was a sign of fertility. In many endemic areas of urinary schistosomiasis, almost all children are infected at a young age (Muller and Morera, 1994). At young age, the boys have more time to go to swim in the canals than girls who stay at home for domestic works.

All six healers knowing intestinal schistosomiasis said that the disease was transmitted by drinking water from the wells. The wells in Niono are shallow and not protected from pollution. Only one healer mentioned that intestinal schistosomiasis could be transmitted if one enters in contact with a water source inhabited by snail and was the only healer considered with adequate knowledge on the mode of transmission of intestinal schistoso-

miasis. To link the transmission of intestinal schistosomiasis to drinking water is probably lack of knowledge about that form of the disease. Usually the oral route is considered by many people as the route of entry of any intestinal infection. This could probably be the case for the healers in Niono, claiming having knowledge on the symptoms of intestinal schistosomiasis.

3.3. Types of treatments of schistosomiasis

All interviewed healers (100%) reported using medicinal plants for the treatment of schistosomiasis. None of the healers were using conventional medicines. Thirty-eight (95%) healers informed about at least one plant for treatment of the disease and the way the remedy was prepared; 31 (77%) reported two plants, while 18 (45%) gave examples of three plants for the treatment of schistosomiasis. Fifty-five different plant species were reported for the treatment of both types of schistosomiasis, either used as single or in combination remedies. The 54 identified species belong to 31 families, and one of these plants was not identified, therefore is not included in the discussion of the present report (Table 1). Two healers (5%) (one from Niono and the other from Diabaly) did not give the names of the plants they were using for treatment of schistosomiasis. These healers considered their knowledge as a secret that should not be unveiled to “outsiders”. Outsider is referred as someone, who does not belong to the family of the healers.

3.4. Plants used for the treatment of schistosomiasis

The plants used for the treatment of both types of schistosomiasis are presented in Table 1. The plants presented in Table 1 represent the plants reported by healers categorized with adequate knowledge about symptoms of urinary schistosomiasis. All the plants reported to be used against intestinal schistosomiasis are also included in the table. Sixteen plants were reported by healers categorized as having inadequate knowledge about symptoms of urinary schistosomiasis. These plants were used either alone or in combination and were *Leptadenia hastata*, *Heliotropium indicum*, *Capparis tomentosa*, *Detarium microcarpa*, *Tamarindus indica*, *Stylosanthes erecta*, *Euphorbia hirta*, *Ricinus communis*, *Gardenia erubescens*, *Gardenia sokotensis*, *Gardenia ternifolia*, *Citrus aurantifolia*, *Cissus quadrangularis*, *Aframomum latifolium*, *Annona senegalensis* and *Leucas martinicensis*. Nine of the 16 plants reported by healers with inadequate knowledge about symptoms of urinary schistosomiasis have also been reported by healers categorized with adequate knowledge (Table 1). This could be due to the fact that these plants are used in other urinary infections and the healers with inadequate knowledge considered schistosomiasis infection as any other urinary infection. Thirty-nine plant species belonging to 20 families were reported to be used alone against urinary schistosomiasis. Nine different combinations of two plants were used, while five different combinations of more than three plants were reported. In both cases (alone or combination) *Stylosanthes erecta* and *Cissus quadrangularis* were the two most frequently used species. In most of the combinations the remedy was prepared with the fruits of either *Tamarindus indica* or *Citrus*

aurantifolia. One recipe was reported to be made with the insect cantharid. Eighty-four percentage of the recipes were prepared by decoction of the plant material fresh, dried or powdered. The length of the treatment of urinary schistosomiasis varied from 1 to 30 days (9.81 ± 1.32 days) depending, according to the healers on the plant toxicity, part of plant used and the mode of preparation. The longest period of treatment was observed with leaf of the plant *Leucas martinicensis* (30 days) and the shortest treatment length was reported for roots of *Annona senegalensis* (1 day). However, the length of the treatment was much shorter when plants were combined and then the doses were also reduced.

The healers who said that they knew about intestinal schistosomiasis have reported eight plants for its treatment (Table 1). All the plants used to treat intestinal schistosomiasis were also used to treat urinary schistosomiasis except *Zea mays* and *Glossonema boveanum*. The healer who mentioned the intermediate host and whose knowledge on the symptoms of intestinal schistosomiasis was adequate reported *Euphorbia hirta* and *Glossonema boveanum* as treatment of the disease. There were three different combinations of plants and two plants used as single remedies. All the remedies, with the exception of two, were prepared as decoction. The length of treatment of the intestinal schistosomiasis varied as for the urinary schistosomiasis depending on the plants species and the parts of the plant used. However, the length of the treatment was much longer than for that of the urinary schistosomiasis. The mean length of the treatment was 13.05 ± 7.35 days. Although the same plants often were used for treatment of both forms of schistosomiasis, the dosage was stronger for intestinal as compared to the urinary form of the disease. Similarly the length of treatment was also longer for the intestinal schistosomiasis. The use of same plants for the treatment of both forms of the disease could be in accordance with the bio-medical chemotherapy of the disease. In the modern biomedicine for treatment of both urinary and intestinal schistosomiasis, a single dosage of praziquantel is used. *Schistosoma haematobium* and *Schistosoma mansoni* have, however, been shown to have different susceptibilities towards some chemicals (Kusel and Hagen, 1999).

3.5. Literature review on traditional uses and biological activities of the most cited plants

It is common among healers not using the same plants, and even when doing so, there will be a difference in the mode of preparation, or different parts of plants will be used. Our results are consistent with previous studies carried out in two other districts (Kayes and Bandiagara) in Mali (Sylla, 1991a,b). However, in these studies six species were found to be used in both areas despite the long distance between them (more than 1000 km). These six species were *Balanites aegyptiaca*, *Securidaca longepedunculata*, *Calotropis procera*, *Arachis hypogae*, *Cassia sieberiana* and *Ziziphus mucronata*. During our survey, these six species were reported by the healers in Niono as well. It is interesting to note that all of these six plants were reported by healers with adequate knowledge about symptoms of urinary schistosomiasis. Four other plant species reported from

Table 1
Plants used for the treatment of schistosomiasis by traditional healers in the Office du Niger, District of Niono

Species (family) [Bambara name, voucher no.]	Parts used	Recipe	Indication (urinary or intestinal schistosomiasis)	Locality of recipe
Combination remedy				
<i>Afromomum latifolium</i> (Afz.) K. Schum. (Zingiberaceae) [Niamacoubara, voucher no. 00143]	Fruit	The fruits of the plant are pulverized with root or root bark of <i>Trichilia emetica</i> Vahl (Meliaceae). One coffee spoon of the powder is added to lukewarm water and drunk twice a day. One can add the powder to porridge or milk. The treatment lasts for 2 weeks	Urinary	Diabaly
	Berries	The dried berries are milled and mixed with powder of root of <i>Entada africana</i> . Swallow 1 coffee spoon of the powder with a little amount of water every morning before meals for 8 days	Intestinal	Nionokoroni
<i>Ampelocissus grantii</i> (Baker) Planch. (Vitaceae) [Forokofaraka, voucher no. 01121]	Tubercles	Copiously wash the tubercles. Make a decoction with <i>Tamarindus indica</i> L. (Fabaceae) (voucher no. 01545)(leaf, bark or fruit). Drink 1/4 l in the morning for 4 days	Urinary	Siby
<i>Calotropis procera</i> (Aiton) W.T. Ait (Asclepiadaceae) [Fogofogo, voucher no. 00730]	Root	Make a decoction of the root of the plant with leafy part of <i>Stylosanthes erecta</i> . Drink about 1/8 l once a day for 30 days	Urinary	Dongaly
<i>Capparis tomentosa</i> Lam. (Capparidaceae) [Dongari, voucher no. 03300]	Leaf/root	A decoction of leaves or roots of the plant is made with leaves of <i>Ricinus communis</i> L. (voucher no. 00208) and roots of <i>Euphorbia balsamifera</i> Aiton (Euphorbiaceae) (voucher no. 00053). Drink one teacup of this decoct in the morning for 8 consecutive days	Urinary	Boh
<i>Cissus quadrangularis</i> Linn. (Vitaceae) [Woulodiolo, voucher no. 01249]	Root/aerial part/whole plant	Make a decoction of the either of the plant parts with fruit of <i>Tamarindus indica</i> (or add to the decoct butter of <i>Vitellaria paradoxa</i> (<i>beurre de karate</i> in French) and drink two teacups (infant) and 1/2 l (adult) twice a day for 3–15 days	Urinary	Barikoro, Diabaly, Diambé, Nionokoroni, Siby, Niono
		The dried whole plant is added to wash water from grain of <i>Sorghum bicolor</i> (L.) Moench (Poaceae) and a decoction was prepared. Drink 1/4 l the evening at bedtime for 3 consecutive days (men) or 4 days (women)	Urinary and intestinal	
		Combination remedy: make a decoction of the whole plant with aerial part of <i>Stylosanthes erecta</i> and fruit of <i>Tamarindus indica</i> . After cooling add some honey. Drink 2 teacups the morning after meal. Continue the treatment until recovery		
<i>Citrus aurantifolia</i> (Christm.) Swingle (Rutaceae) [Lemourou-koumouni, voucher no. 00137]	Leaf/fruit	A powder of the aerial part of the plant is mixed with that of root of <i>Zingiber officinale</i> Roscoe (Zingiberaceae) (voucher no. 00172). Add 1 coffee of the powder in porridge (<i>bouillie</i> in French) without sugar and milk. Drink 2–3 times a day for 1–3 weeks		
	Fruit	Decoction with leaves of <i>Tamarindus indica</i> . Drink 1 teacup three times a day for 3 days	Urinary	Kalancoura
<i>Combretum micranthum</i> G. Don (Combretaceae) [Ngolobé, voucher no. 00031]	Leaf	Decoction of chopped fruits with those of <i>Tamarindus indica</i> . Drink 3 teacups once	Urinary	Diambé
		Mix with the leaves of the plant with whole plant of <i>Cissus quadrangularis</i> and aerial part of <i>Stylosanthes erecta</i> . Make a decoction. Drink 1/2 l every morning for 30 days	Urinary	Diabaly

<i>Euphorbia hirta</i> Linn. (Euphorbiaceae) [Dabadableni, voucher no. 00952]	Whole plant	The powder from the whole plant is mixed with equal amount of powder of aerial part of <i>Cissus quadrangularis</i> . Make a decoction of the both powders and drink 2 teacups 3 times a day for 1 week	Intestinal	Niono
<i>Leptadenia hastata</i> (Pers.) Decne (Asclepiadaceae) [Nzongnè, voucher no. 001197]	Aerial part	Make a decoction with fruits of <i>Tamarindus indica</i> or <i>Citrus aurantifolia</i> and drink 21 daily for 4 days	Urinary	Heremakono
<i>Lonchocarpus laxiflorus</i> Guill. & Perr. (Fabaceae) [Sonioukou, voucher no. 00047]	Bark	Aerial parts the plant and that of <i>Cassia nigricans</i> are used to prepare a decoction. Drink 1 teacup of the decoct 3 times a day for 15 days Decoction of the bark with aerial parts of <i>Stylosanthes erecta</i> and <i>Cissus quadrangularis</i> . After cooling add fruit of <i>Tamarindus indica</i> and drink 1 teacup twice a day for 15–30 days	Urinary	Niono
<i>Nymphaea micrantha micrantha</i> Vent. (Nymphaeaceae) [voucher no. 01828]	Whole plant	Decoction of the whole part with roots of <i>Citrus aurantifolia</i> and drink 1 teacup three times a day after meal. A vapor bath is also possible. The treatment lasts for 10 days	Urinary	Niono
<i>Saba senegalensis</i> (A. DC.) Pichon (Apocynaceae) [Zaban, voucher no. 00082]	Leaf	Make maceration with fruit of <i>Tamarindus indica</i> or <i>Citrus aurantifolia</i> and drink 21 daily for 4 days	Urinary	Niono
<i>Stylosanthes erecta</i> P. Beauv. (Fabaceae) [Segoufali, voucher no. 00170]	Aerial part	Make a decoction and add either fruit of <i>Tamarindus indica</i> or butter of <i>Vitellaria paradoxa</i> and drink 2 teacups 2–3 times a day for 3–8 days	Urinary and intestinal	Barikoro, Ndebougou Séribala, Heremakono, Kalancoura, Diambé, Niono
<i>Ximenia americana</i> L. (Olacaceae) [N'tonguè, voucher no. 00764]	Root	Decoction of the plant with fruit of <i>Tamarindus indica</i> and leaves of <i>Heliotropium indicum</i> L. (Boraginaceae). Drink 2 teacups 3 times a day for 3 days Make a decoction of the powder of <i>Stylosanthes erecta</i> with aerial part of <i>Peritrophe bicalyculata</i> , root of <i>Ximenia americana</i> , bark of <i>Ficus platyphylla</i> Delile (Moraceae) (voucher no. 01814), root bark of <i>Zizyphus mucronata</i> Willd (Rhamnaceae) (voucher no. 01936) and fruit of <i>Xylopiya aethiopica</i> (Dunal) A. Rich. (Annonaceae) (voucher no. 00152) and drink 1 teacup twice a day for 3 days	Urinary, intestinal	Niono
<i>Zea mays</i> L. (Poaceae) [Kaba, voucher no. 00254]	Spike	Calcinate the spike of the maize. Mix it with the powder of leaves of <i>Glossonema boveanum</i> Hochst & Steud ex Decne (Asclepiadaceae) (voucher no. 00142) and that of leaves of <i>Opilia celtidifolia</i> (Guill & Perr.) Endl. Ex Walp (voucher no. 00904). Add 1 coffee spoon of the powder in thin porridge of millet or sorghum. Drink once a day for 4 days	Intestinal	Nionokoroni
Single remedy <i>Allium cepa</i> L. (Liliaceae) [Diaba, voucher no. 00162]	Bulb	Make a decoction of the bulbs. Drink about 1/21 twice a day for 8 days	Urinary	Niono

Table 1 (Continued)

Species (family) [Bambara name, voucher no.]	Parts used	Recipe	Indication (urinary or intestinal schistosomiasis)	Locality of recipe
<i>Aloe buettneri</i> Berger (Lilaceae) [Ndoloboua, voucher no. 01005]	Root	Make a decoction of dried or fresh material and drink 1/2 teacup (infant) and 1 teacup (adult) daily for 4 days	Urinary	Kourouma
<i>Annona senegalensis</i> Pers. (Annonaceae) [Mandesun, voucher no. 00012]	Root	Mix powder of the root of the plant with powder of the cantharid. Macerate the content of one shell of peanut of the mixed powder over night. Drink once. Inflorescence of millet could be added to the mixture	Urinary	Kourouma
<i>Anogeissus leiocarpa</i> (DC). Guill. & Perr. (Combretaceae) [Ngalama, voucher no. 00376]	Leaf	Make a decoction of the leaves (dried or fresh). Drink 1/4 l once a day for 8 days	Urinary	Yayawèrè
<i>Balanites aegyptiaca</i> (L.) Delile (Zygophyllaceae) [Zeguènè, voucher no. 02015]	Root	One coffee spoon of the powder of the dried roots is added to 1/4 l of sour milk. Drink the mixture once a day for 4 days	Urinary	
<i>Cadaba farinosa</i> Forssk. (Capparidaceae) [Minzin, voucher no. 01037]	Leaf	Decoction of the leaves and drink 2 teacups per day for 6 days	Urinary	Km 26
<i>Cassia italica</i> (Mill.) Spreng. (Fabaceae) [Balibali, voucher no. 00962]	Leaf	Make a decoction of the leaves and drink 1 table spoon per day for 3 days. The treatment can be repeated 3 times with the same decoction	Urinary	Dongaly
<i>Cassia nigricans</i> Vahl. (Fabaceae) [Niokorokalani, voucher no. 00902]	Whole plant	The dried material is milled and suck 2 coffee spoons of the power twice a day for 8 days	Urinary	
<i>Cassia sieberiana</i> DC. (Fabaceae) [Sinja, voucher no. 00971]	Leaf	Make a decoction of the leaves and drink 1/4 l the morning before breakfast and treatment can last 8 days	Urinary	Fiébougou
<i>Cissus quadrangularis</i> Linn. (Vitaceae) [Wouloudioloko]	Whole plant	Dry and mill it. Make a decoction and drink 2 teacups twice a day (infant) and 1/2 l 3 times a day (adult)	Urinary	Niono
<i>Cochlospermum tinctorium</i> Perr. (Cochlospermaceae) [N'tiribara, voucher no. 000375]	Leaf	Decoction and drink 1 teacup per day for 8 days	Urinary	M'Bewala
<i>Leucas martiniensis</i> (Jacq.) R. Br. (Lamiaceae) [Dagasiguidagadala, voucher no. 00807]	Whole plant	Make a decoction and drink 2 teacups at the morning before meal for 7 days	Urinary	Fiébougou
<i>Entada africana</i> Guill & Perr. (Mimosaceae) [Samanéré, voucher no. 01799]	Root	Maceration of the powder with fruits of <i>Tamarindus indica</i> and drink 1 coffee spoon twice per day for 3 days	Urinary	Kourouma

<i>Euphorbia hirta</i> Linn. (Euphorbiaceae) [Dabadableni, voucher no. 00952]	Whole plant	Decoction of the dried or powdered material. Drink 1/4 l once the morning before meal for 7 days	Urinary	Niono Heremakono
<i>Ficus thonningii</i> Blume (Moraceae) [Dougalen, voucher no. 00094]	Leaf	Make a decoction of the leaves and drink 2 teacups 3 times a day for 30 days	Intestinal	Nionokoroni
<i>Peristrophe bicalyculata</i> (Petz.) Nees (Acanthaceae) [Barakala, voucher no. 01141]	Aerial part	Make an infusion of the powder. Filter. Drink 1/4 l twice per day for 4 days	Urinary	Siby
<i>Securidaca longepedunculata</i> Fresn. (Polygalaceae) [Djoro, voucher no. 00058]	Root	Maceration of the root and drink one teacup (infant) or 1/2 l (adult) twice per day for 8 days	Urinary	Ndébouyou
<i>Securinega virosa</i> (Roxb. Ex Willd.) Baill. (Euphorbiaceae) [Ndjene, voucher no. 01356]	Root	Decoction and drink	Urinary	Toumakoro
<i>Stylosanthes erecta</i> P. Beauv. (Fabaceae) [Segoufali, voucher no. 00170]	Aerial part	Make a decoction. Inhalate the vapors and bath with some and drink 1/2 l every day for 9 days	Urinary	Barikoro, Ndébouyou Séribala, Heremakono, Kalankoura, Diambé, Niono Heremakono
<i>Vitellaria paradoxa</i> C.F. Gaertn. (Sapotaceae) [Chii, voucher no. 00137]	Root	Chopped dried roots are milled and a pinch of three fingers of the powder is added to porridge (in French: <i>bouillie</i>). Drink the porridge twice a day for 15 days	Urinary	
Zanbaraba ^a [voucher no. 00805]	Leaf	Decoction and drink 1 teacup twice a day for 30 days	Urinary	Diambé

The local names as well as the voucher numbers of the plants are given.

^a Bambara name of the plant not identified by its botanical name.

our survey were also reported to be used against schistosomiasis either in Bandiagara or in Kayes. These were *Gardenia ternifolia*, *Cassia nigricans*, *Ximenia americana* and *Euphorbia hirta*. Out of these four, only *Gardenia ternifolia* was reported by healers with inadequate knowledge about symptoms of urinary schistosomiasis. However, *Euphorbia hirta* was reported only by one healer in Bandiagara and not in Kayes. Therefore our discussion will mainly focus on plants frequently used and not reported before in other studies in Mali for use against schistosomiasis. *Stylosanthes erecta* whole plant, *Cissus quadrangularis* aerial part, *Euphorbia hirta* whole plant, *Annona senegalensis* root, *Balanites aegyptiaca* root and *Peritrophe bicalyculata* aerial part were the most frequently used plants against urinary schistosomiasis in the Niono District. After cross tabulating the level of knowledge on symptoms of schistosomiasis (urinary or intestinal) with the mode of transmission or the plants used, the following plants were associated with the level of knowledge: *Cissus quadrangularis*, *Stylosanthes erecta*, *Cassia sieberiana*, *Securidaca longepedunculata*, *Trichilia emetica*, *Balanites aegyptiaca*, *Calotropis procera*, *Peristrophe bicalyculata*, *Cadaba farinosa*, *Afromomum latifolium*, *Zyziphus mucronata* and *Capparis tomentosa*.

Annona senegalensis and *Balanites aegyptiaca* were reported before to be used against schistosomiasis in Kayes and Bandiagara (Sylla, 1991a,b). The fruit of *Balanites aegyptiaca* is used in folk medicine as a purgative, vermifuge and less commonly for treatment of schistosomiasis. The effectiveness of *Balanites aegyptiaca* fruits was assessed against *Fasciola gigantica* burdens in goats compared with albendazole. Nine grams per kilogram body weight of the fruit mesocarp showed anthelmintic efficacy of 92.3%, while 20 mg/kg albendazole exhibited 97.7% efficacy (Koko et al., 2000). To test the hypothesis that diosgenin, a steroidal saponin from *Balanites aegyptiaca*, might alter the host's hormonal milieu, making a less hospitable environment for adult schistosome, an experiment was carried out on mice by feeding the animals with the compound. The results showed that the diosgenin-fed animals have augmented rather than decreased the response to the disease (Phillips-Conroy and Knopf, 1986).

Cissus quadrangularis and *Stylosanthes erecta* were reported for the first time to be used against schistosomiasis in Mali. However, *Cissus quadrangularis* was reported in Kayes to be used as a molluscicidal plant (Sylla, 1991a) and as a wound healing plant in Bandiagara (Inngjerdingen et al., 2004). *Ricinus communis* leaf in association with *Capparis tomentosa* leaf; *Trichilia emetica* root in association with *Afromomum latifolium* fruit and *Zyziphus mucronata* root bark in association with *Stylosanthes erecta* whole plant were also reported to be used against the disease. In other African countries these plants, except *Stylosanthes erecta*, have been reported to be used by traditional healers for treating urinary schistosomiasis (Clark et al., 1997; Sparg et al., 2000). An extensive literature search on biological activities and medicinal uses of the plants was carried out. There was limited information about the plants most frequently cited, particularly with regard to the use against schistosomiasis. However, a few studies were reported on some of the other plants, either on their medicinal use against schistosomiasis or for having been tested for their anti-schistosome or molluscicidal activities. Extracts

of *Trichilia emetica*, *Ricinus communis* and *Zyziphus mucronata* were lethal against schistosomula worms at a concentration of 50 mg/ml. Among these plants, *Trichilia emetica* was the most active showing a lethal effect on schistosomula at 6.25 mg/ml (Sparg et al., 2000). However, in an other study the extracts of the three plants were found to be more active against cestodes than schistosomula (Mølgaard et al., 2001).

It is interesting to note that most of the combination remedies in the present study were prepared by addition to the preparation of the fruits of *Tamarindus indica* or those of *Citrus aurantifolia*. The fruits of *Tamarindus indica*, in decoction or maceration, are used as common beverages in Mali. The use of the sap of *Cissus quadrangularis* with tamarind has been reported in East Africa for the treatment of gonorrhoea (Burkill, 2000). Addition of sour products to medicine is common among traditional healers in Mali. In our study some remedies were reported to be taken with liquefied porridge made from millet or with fresh milk. Most of the plants in our survey are bitter in taste and therefore the use of fresh milk or millet porridge could improve the taste of the remedy. Addition of butter from the fruit of *Vitellaria paradoxa* C.F. Gaertn. (Sapotaceae) to the remedy was also reported. Ndamba et al. (1994) reported addition of plant material used against schistosomiasis to thick porridge made from the bean fruits of *Phaseolus vulgaris* L. (Fabaceae), this was largely to improve the palatability of the medicine. Ndamba et al. (1994) on the other hand found that the Doctrine of Similitude or Signatures in reference to the color of the part of the plant used (mainly red) as blood was the main symptom associated with the disease. The most common mode of preparation of the remedies was by decoction of the plant material fresh, dried or powdered. Inngjerdingen et al. (2004) reported that decoction was the most common mode of preparation of remedies for wound healing in Dogonland (Mali).

4. Conclusion

An ethnopharmacological survey was conducted in the Office du Niger (Niono District), in Mali among 40 healers from six different health areas. Most healers in our survey related schistosomiasis to haematuria, which is in accordance with the bio-medical terms of the symptoms of the disease. Thirty-three of the 40 healers interviewed had adequate knowledge about urinary schistosomiasis, while only four healers were categorized with adequate knowledge about intestinal schistosomiasis. Three Bambara words are used by healers for designing urinary schistosomiasis in Niono (*sukune bleni*, *ngorochien* and *damadialan*), while *konona damadialan* is used for intestinal schistosomiasis. The transmission of the disease was linked to water by the majority of the healers but other causes were also mentioned. The healers in Niono were more knowledge about the mode of transmission of the disease as compared to the healers in Kayes and Bandiagara. A total of 55 plant species were reported to be used against schistosomiasis either alone or in combination of which *Zea mays* and *Glossonema boveanum* were specific for intestinal schistosomiasis. *Cissus quadrangularis* and *Stylosanthes erecta* were reported for the first time in Mali to be used against schistosomiasis. Further studies should

be initiated for biological evaluation of some of the remedies in the form they are prepared by healers. The evaluation should also direct towards identification of substances in these plants that may be effective in the treatment of schistosomiasis.

Acknowledgements

The authors wish to sincerely thank the healers of the Niono District for their cooperation during this survey. The government of Mali is thanked for issuing the clearance to conduct the study. We also use this opportunity to thank the staff of the Niono District Health Center as well as the persons in charges of the local health centers visited for their help and especially Salif Diakité and Moussa Haïdara. Our sincere thanks also go to the heads of the villages visited. John Reierstad is thanked for making the map of the study area. The project is funded by the NUFU project Pro22/2002 and one of us (S. Bah) is grateful for the Quota grant.

References

- Burkill, H.M., 2000. The Useful Plants of West Tropical Africa, vol. 5. Royal Botanic Gardens, Kew.
- Chimbari, M.J., Chirebvu, E., Ndelela, B., 2004. Malaria and schistosomiasis risks associated with surface and sprinkler irrigation systems in Zimbabwe. *Acta Tropica* 89, 205–213.
- Chitsulo, L., Engels, D., Montresor, A., Savioli, L., 2000. The global status of schistosomiasis and its control. *Acta Tropica* 77, 41–51.
- Clark, T.E., Appleton, C.C., Kvalsvig, J.D., 1997. Schistosomiasis and the use of indigenous plant molluscicides: a rural South African perspective. *Acta Tropica* 66, 93–107.
- Coulibaly, G., Diallo, M., Madsen, H., Dabo, A., Traoré, M., Keita, S., 2004. Comparison of schistosomiasis transmission in a single- and a double-cropped area in the rice irrigation scheme, 'Office du Niger', Mali. *Acta Tropica* 91, 15–25.
- Dabo, A., Sacko, M., Touré, K., Doumbo, O., Dialo, A., 1995. Epidémiologie de la schistosomiase en milieu périurbain de Bamako (République du Mali). *Bulletin de la Société de Pathologie Exotique* 88, 29–34.
- Diallo, D., 2000. Ethnopharmacological survey of medicinal plants in Mali and phytochemical study of four of them: *Glinus oppositifolius* (Aizoaceae), *Diospyros abyssinica* (Ebenaceae), *Entada africana* (Mimosaceae), *Trichilia emetica* (Meliaceae). Faculte des Sciences, Université de Lausanne, Lausanne, 221 pp.
- Diallo, D., Paulsen, B.S., 2000. Pharmaceutical research and traditional practitioners in Mali: experiences with benefit sharing. In: Svarstad, H., Dhillion, S.S. (Eds.), *Responding to Bioprospecting from Biodiversity in the South to Medicines in the North*. Norway, pp. 133–144.
- Esser, K.B., Semagn, K., Wolde-Yohannes, L., 2003. Medicinal use and social status of the soap berry *endod* (*Phytolacca dodecandra*) in Ethiopia. *Journal of Ethnopharmacology* 85, 269–277.
- Gessler, M.C., Msuya, D.E., Nkunya, M.H.H., Schär, A., Heinrich, M., Tanner, M., 1995. Traditional healers in Tanzania: the perception of malaria and its causes. *Journal of Ethnopharmacology* 48, 119–130.
- Inngjerdigen, K., Nergård, C.S., Diallo, D., Mounkoro, P.P., Paulsen, B.S., 2004. An ethnopharmacological survey of plants used for wound healing in Dogonland, Mali, West Africa. *Journal of Ethnopharmacology* 92, 233–244.
- Jukes, M.C.H., 2002. Heavy schistosomiasis associated with poor short-term memory and slower reaction times in Tanzanian schoolchildren. *Tropical Medicine and International Health* 7, 104–117.
- Koko, W.S., Galal, M., Khalid, H.S., 2000. Fasciolocidal efficacy of *Albizia anthelmintica* and *Balanites aegyptica* compared with albendazole. *Journal of Ethnopharmacology* 71, 247–252.
- Kusel, J., Hagen, P., 1999. Praziquantel—its use, cost and possible development of resistance. *Parasitology Today* 15, 352–354.
- Landouré, A., van der Werf, M.J., Traoré, M., de Vlas, S., 2003. Evaluation of the case management in the integrated schistosomiasis-control programme in Mali. *Annals of Tropical Medicine and Parasitology* 97, 723–736.
- Marston, A., Hostettman, K., 1987. Antifungal, molluscicidal and cytotoxic compounds from plants used in traditional medicine. In: Hostettmann, K., Lea, P.J. (Eds.), *Biologically Active Natural Products*. Clarendon Press, Oxford, pp. 65–83.
- Mølgaard, P., Nielsen, S.B., Rasmussen, D.E., Drummond, R.B., Makaza, N., Andreassen, J., 2001. Anthelmintic screening of Zimbabwean plants traditionally used against schistosomiasis. *Journal of Ethnopharmacology* 74, 257–264.
- Muller, R., Morera, P., 1994. Helminthoses. In: Lankinen, K.S., Bergström, S., Mäkelä, P.H., Peltomaa, M. (Eds.), *Health and Disease in Developing Countries*. Mac Millan, Oxford, pp. 195–209.
- Ndamba, J., Nyazema, N., Makaza, N., Anderson, C., Kaondera, K.C., 1994. Traditional herbal remedies used for the treatment of urinary schistosomiasis in Zimbabwe. *Journal of Ethnopharmacology* 42, 125–132.
- Phillips-Conroy, J.E., Knopf, P.M., 1986. The effects of ingested plant hormones on schistosomiasis in mice: an experimental study. *Biochemical Systematics and Ecology* 14, 637–645.
- Sangho, H., Dabo, A., Coulibaly, H., Doumbo, O., 2002. Prevalence and perception of schistosomiasis in a periurban school of Bamako in Mali. *Bulletin de la Société de Pathologie Exotique* 95, 292–294.
- Sow, S., de Vlas, S.J., Mbaye, A., Polman, K., Gryseels, B., 2003. Low awareness of intestinal schistosomiasis in Northern Senegal after 7 years of health education as part of intense control and research activities. *Tropical Medicine and International Health* 8, 744–749.
- Sparg, S.G., van Staden, J., Jäger, A.K., 2000. Efficiency of traditionally used South African plants against schistosomiasis. *Journal of Ethnopharmacology* 73, 209–214.
- Sylla, A., 1991a. Contribution à l'inventaire des Antibilharziens et Molluscicides Traditionnels dans le cercle de Kayes. Section de Pharmacie, Ecole Nationale de Médecine et de Pharmacie du Mali, Bamako, 87 pp.
- Sylla, S., 1991b. Contribution à l'Etude des Antibilharziens et Molluscicides Traditionnels dans le cercle de Bandiagara. Section de Pharmacie, Ecole Nationale de Médecine et de Pharmacie du Mali, Bamako, 85 pp.
- Talaat, M., Miller, D.F., 1998. A mass chemotherapy trial of praziquantel on *Schistosoma haematobium* endemicity in upper Egypt. *American Journal of Tropical Medicine and Hygiene* 59, 546–550.
- van der Werf, M.J., de Vlas, S.J., Landouré, A., Bosompem, K.M., Habbema, J.D.F., 2004. Measuring schistosomiasis case management of the health services in Ghana and Mali. *Tropical Medicine and International Health* 9, 149–157.
- Vigneron, M., Deparis, X., Deharo, E., Bourdy, G., 2005. Antimalarial remedies in French Guiana: a knowledge attitudes and practices study. *Journal of Ethnopharmacology* 98, 351–360.
- Whitfield, P.J., 1996. Medicinal plants and the control of parasites. *Royal Society of Tropical Medicine and Hygiene* 90, 596–600.
- WHO, 2002. First Report of the Joint WHO Expert Committees on the Prevention and Control of Schistosomiasis and Soil-transmitted Helminthes. World Health Organization, Geneva, 268 pp.
- Yapi, Y.G., Briet, O.J.T., Diabate, S., Vounatsou, P., Akodo, E., Tanner, M., Teuscher, T., 2005. Rice irrigation and schistosomiasis in savannah and forest areas of Côte d'Ivoire. *Acta Tropica* 93, 201–211.