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review paper

***Vigna lanceolata* in the fire-stick farming and the Australian Aboriginal culture**

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Summary: An amphicarpic and tuberous legume yam *Vigna lanceolata* Benth., endemic to Australia, have been having an extraordinary significance in the peculiar type of farming and entire culture of the Aboriginal peoples for tens of millennia. Our review, welding plant and human sciences, offers a concise and informative presentation of the species, by elaborating its taxonomy and morphology, describing its beneficial nutritional and medicinal properties, exploring its ecogeography, with a remarkable population abundance in the northern areas of the continent, assessing its extensive spreading as a consequence of the past fire-use environmental

changes and ways of its wilderness reconnaissance, harvest and food preparation, depicting its role in the Australian Aboriginal art, as one of the most sacred objects in the Dreamtime religion, presenting its vernacular names in 85 extinct and living Australian Aboriginal languages and concluding with opening new horizons of its research, through recently established biodiversity and breeding programmes.

Key words: Aborigine, art, Australia, fire-stick farming, *Vigna lanceolata*

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The Children of the Dream

According to the prevailing theory of the recent African origin of modern humans (*Homo sapiens sapiens*), probably the first and the most important *out-of-Africa* migration started around 70,000 years ago, when the ancestors of the present Aboriginal Australians, Papuans and several other contemporary peoples of South Asia and Oceania took the Southern Dispersal Route, crossing the Red Sea, travelling along the Indian Ocean coast and, via Sundaland and Wallacea, ultimately settled in Sahul, a landmass merging New Guinea, Australia, Tasmania and adjacent islands, at least 65,000 years ago (Bae et al., 2017; Castelli & Di Cesare, 1996; Mikić, 2011; O'Connell et al. 2018; Suppl. File 1).

Although having commenced much later in comparison to the anthropological studies of diverse civilisations in other continents, those of the Australian Aboriginal culture are continuously revealing an extraordinarily ancient society with colossal knowledge on and skill in art, astronomy, biology, ecology, ethnobotany, history, law, linguistics, mathematics and recreational games (Castelli, 1985a; Denham, 2015; Moorwood, 2002). Today, there are about 650,000 declared Aboriginal Australians, making only 2.8% of the total population of the country (ABS, 2017), while majority of classifications identifies up to 30 ethnolinguistic families with around 360 languages, comprising those already extinct and more than 90% heavily endangered living languages and dialects (Bowern, 2012; Suppl. File 2).

A practice of burning the primeval megafauna, designated as *fire-stick farming* and unique merely for Australia, spawned the landscapes widely known as *bushlands*, with meagre but retained initial floristic structure (Castelli, 1985b; Jones, 2012). They serve as a source of what *bush tucker*, an Australian English denomination for easily accessible plant food, such as berries, fungi, grain grasses, nuts or yams, and facilely hunted large animals for meat, like kangaroo (*Macropus* spp.) (Adams et al., 2018). As a consequence, the native Australian yam species, such as *Amorphophallus galbra* F. M. Bailey, *A. paeoniifolius* (Dennst.) Nicolson, *Cayratia trifolia* (L.) Domin, *Dioscorea transversa* R. Br., *D. villosa* L., *Ipomoea aquatica* Forssk., *Ipomoea costata* F. Muel. ex Benth., *Ipomoea diamantinensis* J. M. Black, *Portulaca bicolor* F. Muell., *Typhonium lilifolium* F. Muel. ex Schott and *Vigna lanceolata* Benth., had found a multitude of new ambiances and became staple food for tens of millennia.

Every individual element of the Australian Aboriginal culture, including farming, revolves in a perfect symphony with the others around a kind of cosmic maypole called *Dreamtime* or, in Western Arrernte language, *Altierjinga*, a philosophical and religious concept, meaning *eternal, everwhen, out of time, time before or uncreated* (Castelli, 2002). In a remote epoch, humanoid and supreme progenitor beings, the Kundingas, descended from the sky and settled in the Great Sandy Desert near the great rocky complex of Uluru or Ayers Rock (Castelli & Alessandrini, 1984). During their sojourn and before their definite departure, they *dreamed* the complete Australian territory, searching for wells and other goods marked the paths of these travels, labelled as *dreaming tracks* or *songlines* (Castelli, 1987). By esteeming life, Dreamtime could be considered akin to Christianity (Rainbow Spirit Elders, 2007).

The timeless rock paintings and the mythology of the Aboriginal Australians portray the Kundingas as shape-shifting, with the form of yam as one of the most prominent (Veth et al., 2018; Suppl. File 3). One of the most recurring themes in these tales is a slaughter between Ngardilpi or Big Yam people and Wapurtarli or Little Yam people, ending with peace and with each battlefield becoming a sacred place for yam ceremonies restricted for the initiated males (Spencer, 2010). It is exactly the latter yam, *V. lanceolata*, and its place in the Australian Aboriginal culture we are devoting this amalgam of plant and human sciences.

I come from a land down under

Bearing several names in English, such as *bush carrot*, *Maloga bean*, *native bean*, *parsnip bean*, *pencil yam* or *small yam* (NPGS, 2018), *V. lanceolata* belong to the section *Vigna*, together with around twenty more, including the economically important *V. luteola* (Jacq.) Benth., *V. marina* (Burm.) Merr. and *V. subterranea* (L.) Verdc., as well as to the subgenus *Vigna* of the genus *Vigna* Savi of the tribe *Phaseoleae* Bronn ex DC. (Delgado-Salinas et al., 2011). The infraspecific variability of *V. lanceolata* has been largely recognised, with several analyses of its qualitative and quantitative traits describing the species as highly heterogeneous (Lawn & Holland, 2003) and encompassing a certain number of morphotype groups, like those labelled as Central or Silverleaf (Holland & Butcher, 2012). The previously proposed varieties *angusta* E. Pritz, *filiformis* Benth., *lanceolata* Benth. and *latifolia* C. T. White have been abandoned by all current classifications as insufficiently precise, leaving the issue of updating the genetic and phenotypic convolutedness of the species open (Nubankoh et al., 2015). The chromosome number of *V. lanceolata* is identical to that of its closest botanical relatives, $x = 11$ or $2n = 22$ (Pasquet & Vanderborght, 1999).

During the transition of one half of 19th century into another, the existence of *V. lanceolata* was publicly announced to the worldwide plant science community for the first time (Mitchell, 1848). George Bentham, a British botanist, gave a detailed description of its aboveground organs, such as smooth shoots, elongated stipules, trifoliolate leaves with whole and spear-like leaflets of various widths, slightly lobed in the basal region, and notable aerial flowers on long peduncles and of more or less intense yellow corolla colour (Fig. 1, second and third row). The growth habit of *V. lanceolata* is dominantly prostrate, with long, creeping or vining stems (Fig. 1, first row), and colloquially regarded as a *bush*. The underground organs of *V. lanceolata* are a tap root and relatively short, elongated and moderately thin tuberous formations (Fig. 1, first row), which may produce rhizomes (Saravana Kumar et al., 2012) and which associate the plant with yams, in general, as well as with pencil, carrot (*Daucus carota* L.) and parsnip (*Pastinaca sativa* L.), in particular. The propagation of the species is quite complex, encompassing both vegetative and generative mechanisms. The first is akin to other plants with transformed storage rhizomes, while the seeds, developed by the pollination of chasmogamous flowers and shattered by the clustered and successively maturing dehiscent pods (Fig. 1, fourth row), is responsible for the second one. Apart from these aerial inflorescences, *V. lanceolata* is characterised by amphicarpic flowers, pods and seeds (Figure 1, third row). This represents a kind of genetically-controlled adaptation to persist unfavourable environmental conditions (Lawn & Bielig, 2016).



Figure 1. Some morphological features of *Vigna lanceolata*: (from left to right and from top to bottom) creeping or trailing growth habit typical for isolated plants; tap root and rhizomes; harvested rhizomes; broad leaflets; medium-width leaflets; narrow leaflets; long and upright peduncles; less intense coloured aerial flowers; more intense coloured aerial flowers; colourless amphicarpic flowers; an immature aerial pod; aerial pods assembled in an infructescence; aerial seeds

The genus *Vigna* is represented in the flora of Australia with five species, namely *V. lanceolata*, *V. luteola*, *V. marina*, *V. radiata* (L.) R. Wilczek and *V. vexillata* (L.) A. Rich. (Lawn & Watkinson, 2002), of which the first one is endemic solely to Australia. The Global Biodiversity Information Facility (GBIF) treasures precious, thorough and updating information about the ecogeography of *V. lanceolata*. This species is present in the wild floras of all the states and territories of the Commonwealth of Australia, except the Australian Capital Territory and Tasmania (Fig. 2). Of the total number of 1811 catalogued accessions of *V. lanceolata* in GBIF, almost 91%, that is, 1646, come from the Northern Territory, followed by 83 from Western Australia, 52 from New South Wales, 13 from Queensland, 10 from South Australia and one from Victoria. The single remaining accession in the GBIF database is the only one outside of

the Australian state borders, located in Old Mawata of the Papua New Guinea mainland, with the monsoon climate type (GBIF, 2018).

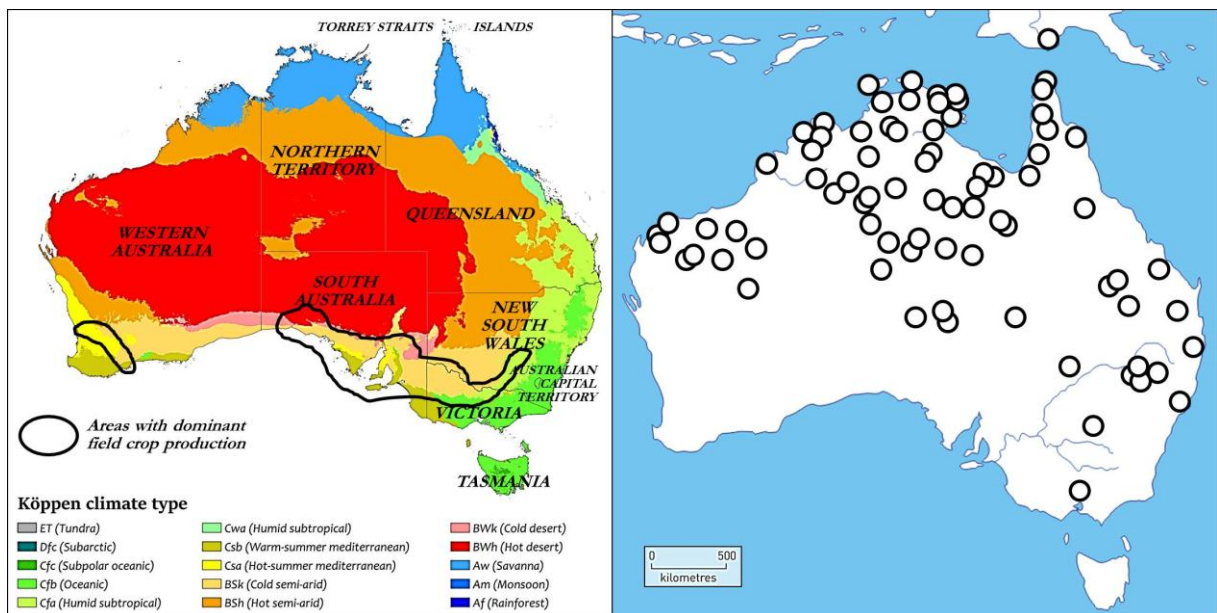


Figure 2. Two comparative maps of the continent of Australia, displaying (left) the distribution of the Köppen climate types across the Australian states, territories and islands, designating the areas with dominant field crop production, and (right) the spatial dispersal of *Vigna lanceolata*, with each circle denoting either one or several geographically close of 1811 catalogued populations, with a single exception of the location recorded in the southernmost mainland of Papua New Guinea, with a monsoon climate (Discover Life, 2018; GBIF, 2018)

The largest portion of the recorded specimens of *V. lanceolata* are kept in the Northern Territory flora atlas in Palmerston, while the remainder is kept in the Western Australian Herbarium in Kensington, the National Herbarium of New South Wales in Sydney, the Australian National Herbarium in Canberra, the Department for Environment and Water in Adelaide, the Kew Gardens in London, UK, the Atlas of the New South Wales Wildlife in Sydney and the Harvard University Herbaria in Cambridge, USA (Discover Life, 2018). The riddle of a striking adaptability of *V. lanceolata* to an ample range of climates becomes even more taunting by the communications about its appreciable ecological compliance to extremely different environments. They cover both natural habitats and man-shaped landscapes, such as close to streams, rivers, creeks, channels, drains, lagoons, gulfs and coasts, in rock holes, next to mines, such as in Pine Creek in the Northern Territory, on sandy flats, downs and hills, in bushlands, grasslands, like the Brigalow Belt in Queensland, and rainforests, near farms and paddocks and along roadsides, highways, railways, airstrips and ports (Lawn, 2015). One of the assumed explanations for the scarcity of *V. lanceolata* in the southern portion of Australia is intensive field crop production and sheep overgrazing during past two centuries (Cahir et al., 2018).

***...Flesh, antidote,
Old rites with flames,
All lines and dots,
Myriad names...***

As in other similar hunter-gatherer societies worldwide, it is the women, who have been acting as the cardinal lore-keepers of yams biogeography (Atchison & Head, 2012), as well as the most experienced searchers for the yellow flowers of *V. lanceolata* and harvesters of its tubers

(Suppl. File 4). Digging for this and other yams with sticks of various materials, like bone, wood or, since short while ago, metal, is quite comparable to ploughing, in terms of turning over soil layers and enhancing its aeration, bettering its water regime and nutrient flow and improving microbial activity, all resulting in higher and tuber yields during next seasons (Butlin, 1993). The underground fibrous fruits, having the taste of *I. batatas*, are eaten raw or baked, according to one of recipes of the seemingly world's oldest cuisines, within a densely handmade heap of earth upon which the fire is lit (Suppl. file 5) and until they lose enough water to become firmer and still desirably juicy (Dyson, 2006).

Since the plants of *V. lanceolata* grow within wild flora, we may merely make a rather unprecise estimation of its tuber yield. On the premises of a medium-sized raw tuber and its chemical composition, with 770 g kg⁻¹ of water, 175 g kg⁻¹ of crude carbohydrates and 28 g kg⁻¹ of crude protein (Maconochie, 1985), the average raw tuber mass varies between 110 g and 120 g or from 0.9 kg plant⁻¹ to 1.5 kg plant⁻¹. These values may be stimulating for the pioneering studies in the *V. lanceolata* production potential if properly cultivated, even if they may be several times lower when compared to economically much more significant yam crops native to other continents and with advanced agronomy, such as *Dioscorea alata* L. (Srivastava et al., 2012). During baking, the water content reduces approximately by half, similarly to other yams (Adelaja et al., 2010). Unlike the products introduced from Europe and North America, such as bread, cakes or pasta that seriously trigger cardiovascular diseases and diabetes among Aboriginal Australians, *V. lanceolata* and other ingredients of their traditional diets have beneficial effects due to a lower glycaemic index with slower release and low fat proportion (Williams, 2012). If prepared as powders or tonics, they may also be potent anti-ageing, anti-inflammatory, anti-hypertensive, anti-neurodegenerative, antioxidant, antithrombic, anxiolytic, cardioprotective, cholesterol-lowering and immunomodulatory agents (Williams, 2013).

A phytolinguistic quest for the vernacular names denoting *V. lanceolata* in the available dictionaries and other lexical resources of nearly every extinct and living Australian Aboriginal languages and dialects identified more than 100 words belonging to 84 spoken languages (Mikić, 2018; Fig. 3 and Suppl. File 6) and one sign language (Iltyem-iltyem, 2018; Suppl. Files 7 and 8) of each ethnolinguistic family. The overlapping between the spatial distribution of the species' populations (Fig. 2, right) and their geographic location of the languages with attested names referring to *V. lanceolata* (Suppl. File 6) may be deemed verily outstanding (AuSIL, 2018). The morphological variability of the compiled popular names is incomparably wider in comparison to other ethnolinguistic families of the world, primarily due to an incomparably longer development. Lexicologically, we may only comment sporadic cases of the congruence between morphology and semantics of the vernacular names referring to *V. lanceolata* in genealogically close languages and dialects, such as in Gurindji, Kunwinjku, Upper Arrernte or Wumbala. There are also examples of the lexical exchange between the languages of different families, like Pilinara and Wardaman.

The etymology of popular names linked to this legume is notably fragmented, but is able to suggest possible roots, such as the Proto-Arandic **manaaty* and its cognates in Wagaya and Waramungu (Koch, 2004) and the Proto-Ngarna **jika* (McConvell & Laughren, 2004), within the Pama-Nyungan languages. The Aboriginal Australians make distinction among the morphotypes of *V. lanceolata* and have distinct name to denote those with extremely narrow leaflets, as seen in the Alyawarre *atnwelarr* and the Warlpiri *kupurturru*. The vernacular names denoting the species also exist in the Australian Aboriginal English, with *'am*, the Papuan languages Meriam, with *lewer*, and Nambu, with *taita*, and the creoles, such as Australian Kriol, with *jarlma*, and Torres Strait Creole, with *yam*.



EMILY
KAME
KNGWARREYE
YAM
DREAMING
1996
SYNTHETIC POLYMER
PAINT ON LINEN
122.0 x 183.0 cm



ALYAWARRE akam	ANMATJIRRA arlatyey; kame	AWABAKAL kokabai	DARKINJUNG wyong	DHUWAL ganguri
DJAPU yukuwa'	DJINANG barlngunda	DJINBA buyurmarr	DYIRBAL dugur	GAMILARAAY guwēai; kubbiai
GUMBAYNGGIR da:m	GURINDJI manaari; wayit; wayita	GUUGU YALANDJI kambayal	GUUGUYIMITHIRR kaabuunh	KALAW LAGAWYA gabau
LOWER ARRERNTE alatyeye	MALNGIN manaari	MANYJILYJARRA mata	MARTU WANGKA kanyjamarra	
MARTUTHUNIRA mada	MAYI-KULAN kowar	NGARINGMAN kagawuli	NGARLUMA mardirra	NHANDA ajuga
NYANGUMARTA kanyjamarra	PILINARA wanymirra	PINTUPI tatupirra; wakati	PITTA PITTA tintama	RITHARNGU ganguri; mawunu
UPPER ARRERNTE arlatyeye	UPPER ARRERNTE (CENTRAL) arlatyeye		UPPER ARRERNTE (EASTERN) arlatyeye	
UPPER ARRERNTE (WESTERN) latyeye; latjiya	WAGAYA menaji	WALMAJARRI jirrirpaja; kujuntu	WALMAJARRI (EASTERN) juwa	
WARLMANPA wabidi	WARLPIRI japirda; ngalajiyi; wajaraki; wapirti; yumurnunju		WARRNAMBOOL tjirang	
WARRONGU ganyo	WARUMUNGU manaji; ngajarrma	YANYUWA yika	YIR-YORRONT thorrchonh; wanychw	

Figure 3. Common names denoting *Vigna lanceolata* in some of the Australian Aboriginal languages and dialects (Mikić, 2018), with the names of languages and dialects in capital letters and the names in lowercase, set in an imaginary two-panel story of the comic character *Martin Mystère*; first panel gives the names in the Pama-Nyungan languages (continued on the next page)

BARDI narrga	BURARRA jaypuriga; mun-garra	DAMIN kurrikurriji m!ii; wiiti m!ii		
ENINDHILYAGWA mwarntakirriyarra	GAAGUDJU djugu-djoogu; moornarn	GAMBERRE wanggalu	GARAWA kabala	
GARAWA (WESTERN) mili	GIIMBIYU liindyi	GOONIYANDI birla	GUNDJEIHM garrbarda	GURAGONE djunja; wartbirritji
IWAIDJA wangkartuk	JAMINJUNG gagawooli	JAWI koolngarie	JINGULU karrangayimi	
KAYARDILD jiwi; thadawa	KIJA ngawoonyji	KUNE kajawal	KUNINJKU karrbarda	KUNWINJKU karrbarda
KWINI wegu	LARAGIYA wila	LARDIL burruku	MALAK-MALAK yeyeynin	
MANYALLALUK karremudyi	MARRANJ warkuja	MATNGELE belerr; derringey; mal	MAUNG arlamun	MIRIWOONG wanmalang
MURRINH-PATHA thalam; wawa	NGARINYIN alamer	NUNGGUBUYU warda	TIWI marntinga; murani; murrunkawini	
WAGIMAN yohyin; yoyin	WAMBAYA jigama	WARDAMAN mordon; 'wayida	WARDARANG dujajaja	
WORRORRAN inkalba; karnmangku; wungunimbim	WUNAMBAL ngulwana	YIIDJI nalangga		



Figure 3. (continued) The second panel lists the names denoting *Vigna lanceolata* in the non-Pama-Nyungan languages; both panels include (second panel, middle row, first from left) the genuine photograph portrait of the most famous Australian Aboriginal artist, Emily Kame Kngwarreye, (first panel, middle row, first from left) the photograph of Ms. Kngwarreye creating in the field and (first panel, top row, third from left) her painting *Yam Dreaming*

Carpe diyam!

Seize the yam! We may say that this enthusiastic slogan finally has its real and optimistic grounds. During the last decade, there has been made a rapid move forward in domesticating *V. lanceolata*, exceptionally likely the first ever done in the entire history of this plant in the continental mass of the Sahul Shelf. The Australian legume research community began to recognise the remarkable potential of *V. lanceolata*, which has already been apprehended for an indefinite time in the past. Thus, today, the knowledge accumulated for tens of millennia and passed from one to another generation of the Aboriginal Australians is inspiring the spurring actions by the Australian governmental institutions in the *in situ* preservation and *ex situ* conservation, accompanied with establishing passport databases, extending ecogeographical notes, formulating descriptors and introducing DArT molecular marker analyses, as in the case of the recent field examinations in the Pilbara region of Western Australia (Lawn & Cottrell, 2018).

In parallel, we are witnessing the genesis of the pioneering efforts in breeding *V. lanceolata*, with controlled hybridisation and developing hybrid generations, articulating the ideotypes of future cultivars, encompassing annual and perennial genotypes, amphicarpic and aerial seed morphotypes and uses in human consumption, pretty similar to Jerusalem artichoke (*Helianthus tuberosus* L.) (Terzić et al., 2012), and animal feeding (Lawn et al., 2016). Such work is based upon thorough studies on the mutual correlations among physiological, morphological and economically important parameters, with emphasis on the duration of growing season, grain yield components, tuber yield and chemical composition (Lawn & Rebetzke 2006).

Apart from the scientific advances relating to *V. lanceolata*, we are also privileged to observe a true resurrection of the Australian Aboriginal art, conceived by and handed over to new generations by the immortal Emily Kame Kngwarreye (Fig. 3), which attracts not only the world-wide recognised connoisseurs, but also the amateurs, to a sacred well of the finest native painting, embedded in the very heart of the Australia continent (McCulloch & McCulloch Child, 2008).

* * *

...Here where they have memorial park

One time lubras dug for yams...

(From the poem *Then and Now* by Oodgeroo Noonuccal; Noonuccal & Walker, 1992)

...I'm really old people now. I want to go home to kagawuli.

(The last wish of the 90-year Ngarinman saltwater man Big Mick Kangkinang; Robin & Heinsohn, 2009)

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Vigna lanceolata u ratarenju vatrom i australskoj urođeničkoj kulturi

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Sažetak: Amfikarpna i krtolasta jamolika mahunarka *Vigna lanceolata* Benth., endemska u Australiji, ima izvanredni značaj u osobenom vidu ratarenja i celokupnoj kulturi urođeničkih naroda tokom desetina milenijuma. Naš pregled, stapajući prirodne i društvene nauke i umetnost, daje kratki i činjenicama bogati prikaz ove vrste, razmatrajući njenu sistematiku i morfologiju, opisujući njena hranljiva i lekovita svojstva, istražujući njenu ekogeografiju, s izuzetnim obiljem populacija u severnim oblastima kontinenta, razjašnjavajući njeno široko rasprostiranje kao posledicu prethodne upotrebe vatre u menjanju životne sredine i načine njenog prepoznavanja u divljini, ubiranja i pripreme u ljudskoj ishrani, oslikavajući njenu ulogu u australskoj urođeničkoj umetnosti, kao jednog od najsvetijih predmeta religije Sanjanja, dajući njena narodna imena na 85 izumrlih i živih australskih urođeničkih jezika i zaključujući otvaranjem novih horizonata njenog istraživanja, putem nedavno začetih programa biodiverziteta i oplemenjivanja.

Ključne reči: Aboridžini, Australija, ratarenje vatrom, umetnost, *Vigna lanceolata*